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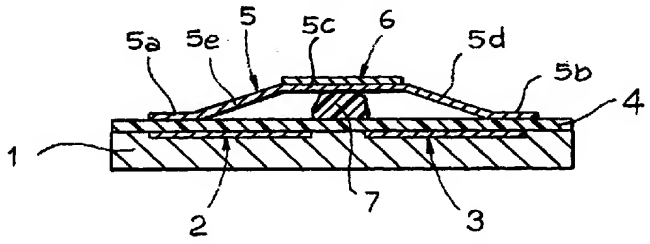
(54) Electrostatically controlled oscillating mirror

(57) An electrostatically controlled oscillating mirror comprises a movable petal (5), constituted by a thin film of electrically conductive material, having at least one end portion connected to a supporting structure (1) and a movable portion carrying a mirror (6). A first electrode (2) and a second electrode (3) are provided carried by the supporting structure. The petal (5) is adapted to be biassed, by electrostatical effect, towards the first electrode (2) or towards the second electrode (3), when voltage is applied respectively between the petal (5) and the first electrode (2), or between the petal (5) and the second electrode (3), so as to cause the mirror to assume different operative positions.

Fig_1



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Description

[0001] The present invention relates to an oscillating mirror device which is electrostatically controlled.

[0002] There have been already proposed in the past electrostatic motors of low power and small dimensions adapted for use as actuators in applications of micro-electronic technology for actuating mechanical devices and the like, in conditions where vibrations take place, such as in the automotive field. These electrostatic actuators make use of flexible sheets, also called cilia or "petals", which are electrically conductive, each having one end associated with a stator and the opposite end adjacent to a movable element. The application of voltage pulses between the petals and one electrode associated with the movable element causes adhesion by electrostatical effect of the petals to the movable element, with a resulting movement of the latter relative to the stator.

[0003] An actuator of the above indicated type is for instance disclosed in Dyatlov V. L., Konyaskin V. V., Potapov B. S. and Pyankov Yu. A., "Prospects of the Employment of Synchrotron Radiation in film Instruments and Methods in Physics Research, A359 (1995), pages 394-395.

[0004] The object of the present invention is that of proposing new and unique applications of electrostatic petals for driving an oscillating mirror.

[0005] In view of achieving this object, the invention provides an oscillating mirror device which is electrostatically controlled comprising:

a mirror,
a supporting structure,
a movable petal, comprising a thin film of electrically conductive material, having at least one end portion connected to said supporting structure and a movable portion carrying said mirror,
a first and a second electrode which are spaced from each other and carried by the supporting structure,
said petal being adapted to be biassed by electrostatical effect, towards the first electrode or the second electrode, when voltage is applied respectively between the petal and the first electrode, or between the petal and the second electrode, so as to cause the mirror to assume different operative positions.

[0006] In a first embodiment, said supporting structure comprises a planar base, on which two thin films of electrically conductive material are applied constituting the first and the second electrodes which have been mentioned above, and said petal is constituted by a thin film having both its ends anchored to the base and a central portion carrying the mirror and resting on the base with the interposition of a spacer element, so that the two portions of the petal intermediate between the central portion and the ends are able to selectively adhere to two electrodes by electrostatical effect, as a function of an activation of one or the other of the electrodes so to arrange the mirror in different operative positions.

[0007] In a second embodiment, the supporting structure comprises a base with an upper surface having a cavity, on which the two thin films of electrically conductive material, which constitute the first and the second electrode are applied, and said petal is constituted by a thin film having both its ends secured to the base and a central portion facing the bottom of said cavity and spaced therefrom, so that said central portion partially adheres by electrostical effect to one side or the other of the bottom of said cavity, depending upon which electrode is activated.

[0008] In a third embodiment, the supporting structure comprises a base with a convex surface, on which a first electrode is applied along with a plate of transparent material facing said convex surface and provided with a layer of electrically conductive transparent material, acting as second electrode, said petal having one end anchored to the supporting structure and a portion movable in the space between the base and the transparent plate, carrying the mirror.

[0009] Further features and advantages of the invention will become apparent from the description which follows with reference to the annexed drawings, given purely by way of non limiting example, in which:

figures 1, 2, 3 show three different operative positions of a first embodiment of the device according to the invention,
figures 4, 5, 6 show three different operative conditions of a second embodiment of the device according to the invention, and
figure 7 is a cross-sectional view of a third embodiment of the device according to the invention.

[0010] With reference to figures 1, 2, 3, the device shown therein comprises a planar base 1 constituted by a sheet of steel or alumina having a thickness of some millimeters. On base 1 two separate electrodes 2, 3 are provided by evaporation, screen-printing, dipping or spin-coating. Subsequently, the surface is insulated by a layer 4 of dielectric or ferroelectric material having a thickness between one tenth of micrometers and some tens of micrometers. The movable part of the device is constituted by a thin metal film 5 provided by evaporation, having a thickness of some micrometers (petal). On the central portion of the upper surface of film 5 a mirror 6 is applied by electro-deposition. Petal 5 has two ends 5a, 5b which are secured to the surface of the base and its central portion, designated by 5c, which rests on the base by means of a spacer element 7 having a rounded shape, made of a friction resistant material, having a low friction coefficient.

[0011] If an electric voltage is applied between petal

5 and electrode 3 the petal portion 5d intermediate between the central portion 5c and the end 5b adheres by electrostatical effect to base 1 (see figure 2) and the mirror 6 is inclined rightwardly (with reference to the drawings). By applying instead a voltage between the petal and the electrode 2, the intermediate portion 5e between the end 5a and the portion 5c of petal 5 adheres by electrostatical effect to the base (figure 3) thus orienting the mirror leftwardly. By applying a voltage alternatively between the petal and electrode 2 or the petal and electrode 3, an oscillation of the mirror is obtained between the two end positions. In operation, all the intermediate positions are also exploited.

[0012] In a variant (see figures 3, 4, 5) base 1 has an upper surface with a cavity 8 having a bottom surface 8a. The petal 5 has its central portion 5c spaced from the bottom part 8a. The alternative activation of the two electrodes 2, 3 causes adhesion by electrostatical effect of the petal 5 against one side or the other of the bottom wall 8a, so as to orient the mirror 6 (see figures 5, 6).

[0013] In a further variant, base 1 is constituted of steel and acts as the first electrode having a convex surface 1a covered by a layer of insulating material 4. The fixed part further includes a plate of transparent material, such as glass, 9 having a surface facing the convex surface 1a and coated with a layer of electrically conductive transparent material (such as Indium Titanium Oxide (ITO)), if necessary with a further dielectric layer (not shown).

[0014] The petal 5 has one end anchored to the fixed part and the movable part projecting in a cantilever fashion in the space between the facing surfaces of base 1 and glass plate 9 and carrying mirror 6. The alternated activation of the electrod 10 associated with the glass plate 9 and the electrode constituted by element 1 causes oscillation of the movable part of petal 5 and the resulting variation in inclination of mirror 6, which receives and reflects light rays through plate 9. From the foregoing description, it is clearly apparent that the device according to the invention is able to drive the oscillation of a mirror simply and efficiently, while using an electrostatically controlled petal as actuator.

[0015] Naturally, while the principle of the invention remains the same, the details of construction and the embodiments may widely vary with respect to what has been described and illustrated purely by way of example, without departing from the scope of the present invention.

Claims

1. Electrostatically controlled oscillating mirror device, comprising:

   a mirror (6),
   a supporting structure (1),
   a movable petal (5) comprising a thin film of electrically conductive material, having at least one end portion 5a connected to said supporting structure (1) and a movable portion carring said mirror (6),
   a first electrode (2) and a second electrode (3) spaced from each other, carried by the supporting structure (1),
   said petal (5) being adapted to be biassed, by electrostatical effect, towards the first electrode (2) or the second electrod (3), when voltage is applied respectively between the petal (5) and the first electrode (2), or between the petal (5) and the second electrode (3), so as to cause the mirror to assume different operative positions.

2. Mirror device according to claim 1, characterised in that the supporting structure comprises a planar base (1) on which two thin films (2, 3) are applied of an electrically conductive material, said films constituting the first and the second electrode, said petal (5) being constituted by a thin film having both ends (5, 5b) anchored to the base (1) and a central portion (5c) carrying the mirror (6) and resting on the base (1) with the interposition of a spacer element (7), so that the two petal portions (5d, 5e) intermediate between the central portion (5c) and the end portions (5a, 5b) are able to selectively adhere to the base (1) depending upon activation of the first electrode (2) or the second electrod (3), so as to arrange the mirror (6) in different operative positions.

3. Device according to claim 2, characterised in that the base carrying the two electrodes (2, 3) are coated with a layer of dielectric material.

4. Device according to claim 1, characterised in that the supporting structure comprises a base (1) with an upper surface having a cavity (8) on which two thin films are applied of an electrically conductive material (2, 3), said films constituting the first and the second electrode, said petal (5) being constituted by a thin film having both ends anchored to the base (1) and a central portion (5c) facing the bottom wall (8a) of said cavity and spaced therefrom, so that said central portion (5c) of the petal (5) partially adheres by electrostatical effect to one side or the other of the bottom (8a) of said cavity, depending upon activation of the first electrode (2) or the second electrod (3).

5. Device according to claim 4, characterised in that said base (1) is coated with a layer of dieletric material (4).

6. Device according to claim 1, characterised in that the supporting structure comprises a base (1) of an electrically conductive material, constituting the first

electrode and having a convex surface (1a) and a plate of transparent material (9) facing said convex surface (1a) and provided with a layer of electrically conductive transparent material (10) acting as the second electrode, said petal (5) being anchored at one end to the supporting structure and having a movable portion projecting in cantilever fashion in the space between the convex surface (1a) and said transparent plate (9) on which the mirror (6) is arranged, so that said movable part of the petal (5) is biassed towards the base (1) or towards the transparent plate (9) depending upon activation of the first electrode or the second electrode.

7. Device according to claim 6, characterised in that said base is provided with a layer of dialelectric material (4).

Fig_1

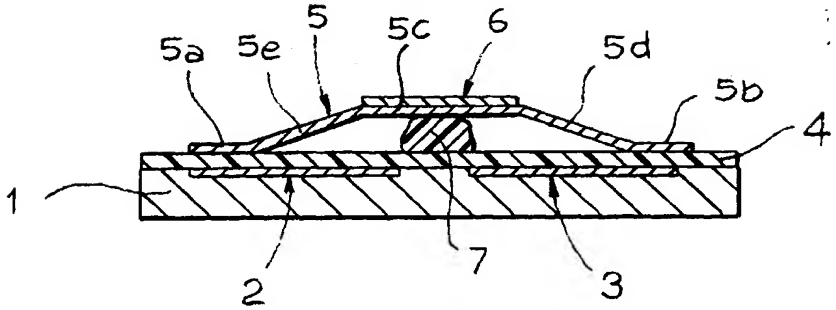


Fig_2

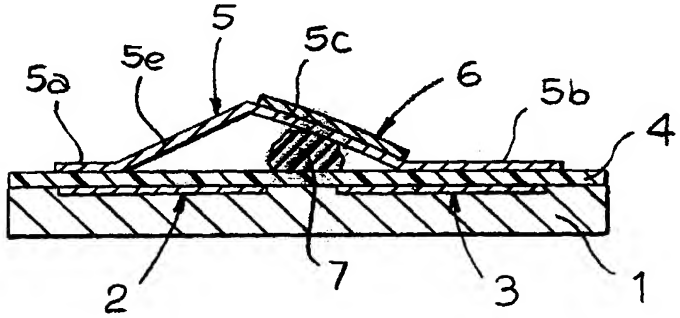


Fig_3

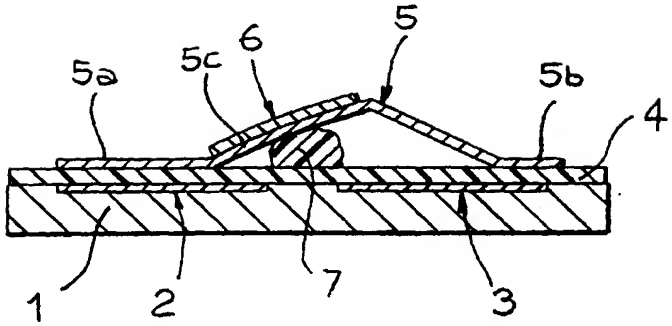


Fig_4

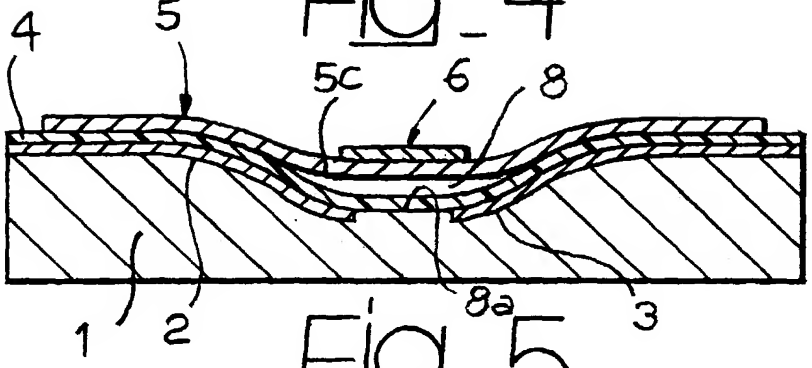


Fig_5

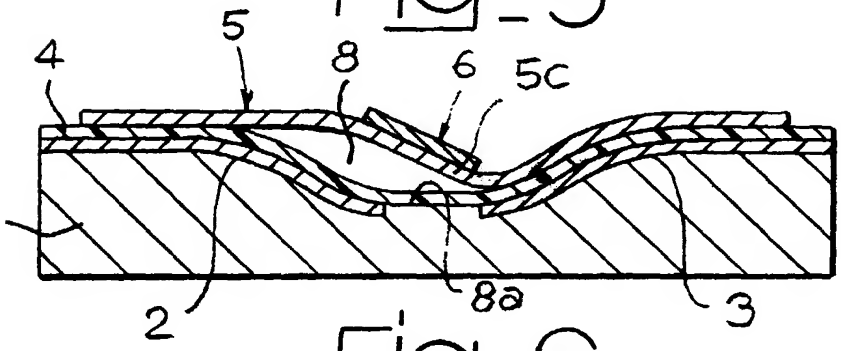


Fig_6

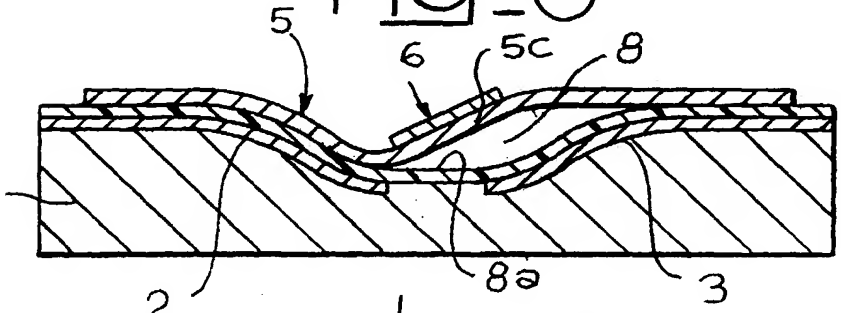
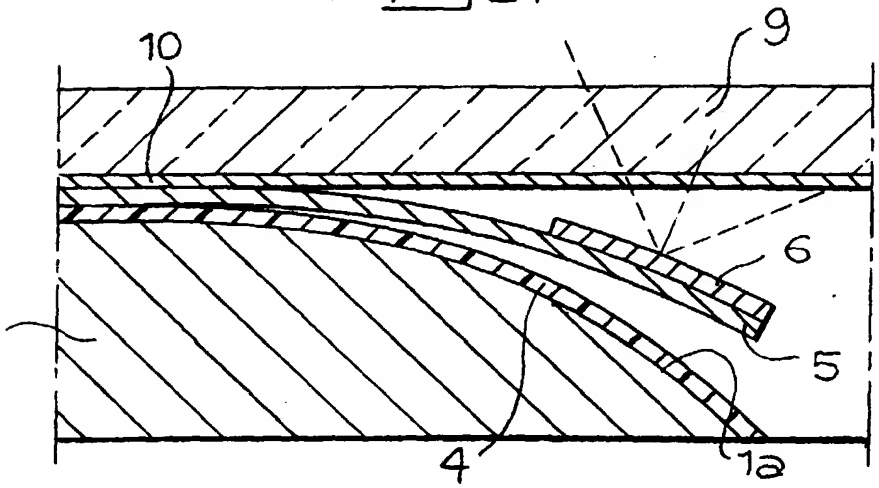


Fig_7



European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 99 83 0729

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Y	* column 3, line 56 - column 6, line 13; figures 1-3B *	4,5	G02B26/02
X	WANG P K C ET AL: "A METHOD FOR DESIGNING ELECTROSTATIC-ACTUATOR ELECTRODE PATTERN IN MICROMACHINED DEFORMABLE MIRRORS" SENSORS AND ACTUATORS A,CH,ELSEVIER SEQUOIA S.A., LAUSANNE, vol. A55, no. 2/03, 31 July 1996 (1996-07-31), pages 211-217, XP000641647 ISSN: 0924-4247 whole document * figures 1,4 *	1	
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Y	* column 11, line 48 - column 13, line 27; figures 11-15 * * column 5, line 62 - column 6, line 3 *	7	

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
MUNICH	6 March 2000	Casse, M

CATEGORY OF CITED DOCUMENTS

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Y : particularly relevant if combined with another document of the same category
A : technological background
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P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

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European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 99 83 0729

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
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& : member of the same patent family, corresponding document

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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 99 83 0729

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06-03-2000

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

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EUR-CL (EPC): G02B007/182

ABSTRACT:

CHG DATE=20000901 STATUS=O> An electrostatically controlled oscillating mirror comprises a movable petal (5), constituted by a thin film of electrically conductive material, having at least one end portion connected to a supporting structure (1) and a movable portion carrying a mirror (6). A first electrode (2) and a second electrode (3) are provided carried by the supporting structure. The petal

(5) is adapted to be biassed, by electrostatical effect, towards the first electrode (2) or towards the second electrode (3), when voltage is applied respectively between the petal (5) and the first electrode (2), or between the petal (5) and the second electrode (3), so as to cause the mirror to assume different operative positions. □